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EVALUATION OF A SAMPLE OF KAOLIN FROM BLACK ISLAND, MANITOBA AS SOURCE MATERIAL FOR THE PAPER INDUSTRY

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EVALUATION OF A SAMPLE OF KAOLIN FROM BLACK ISLAND, MANITOBA AS SOURCE MATERIAL FOR THE PAPER INDUSTRY

by

P.R.A. Andrews*

SUMMARY

A sample of kaolinitic sand from Black Island, Manitoba was subjected to scrubbing and washing to remove a silica grit reject product (+44 μm). The remaining -44 μm fraction was further deslimed at 2 μm and the intermediate -44 +2 μm fraction was successfully upgraded to 80% kaolin by flotation. The recovery, however, was only fair at 48.6%. Further flotation testwork should improve the recovery to more acceptable levels.

Magnetic separation was only partially successful; ~30% of both the iron oxides and ilmenite were rejected from the -44 μm fraction.

The concentration of kaolin in the -4 μm fraction as determined by the laboratory Bahco air classifier was ~85%.

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ÉVALUATION D'UN ÉCHANTILLON DE KAOLIN DE BLACK ISLAND (MANITOBA) EN TANT QUE MATIÈRE PREMIÈRE POUR L'INDUSTRIE DU PAPIER

par

P.R.A. Andrews*

RÉSUMÉ

Un échantillon de sable kaolinitique de Black Island (Manitoba) a été nettoyé et lavé pour en extraire le produit de rebut composé de particules abrasives de silice (+44 µm). La fraction restante de -44 µm a été nettoyée en enlevant la boue à 2 µm et la fraction intermédiaire -44 +2µm a été valorisée par flottation à une teneur en kaolin de 80 %. Cependant, le taux de récupération qui était de 48,6 % n'était que passable. Des essais de flottation additionnels devraient permettre d'obtenir un meilleur taux de récupération.

La séparation magnétique n'a réussi que partiellement; ≈30 % de l'oxyde de fer et ≈30 % de l'ilmenite ont été rejetés de la fraction de -44 µm.

La concentration de kaolin dans la fraction -4 µm telle que déterminée en laboratoire au moyen de l'appareil de classement d'air Bahco était de ≈ 85 % .

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INTRODUCTION

Black Island is situated in Lake Winnipeg, approximately 140 km north of Winnipeg. The kaolin occurs as a band in association with an 11 m thick band of silica sand. The silica sand, which is mined and processed by Steel Brothers Ltd., is the only mineral currently being processed.

As part of the Manitoba Mineral Development Agreement, a sample of Black Island kaolin was obtained for evaluation as filler grade kaolin for the paper industry.

In an earlier study[1] the greatest concentration of kaolin was obtained in the -1.5 µm fraction but no data are available as to the degree of concentration. An illitic material and a minor quantity of an iron mineral were the principal contaminants. The main conclusion was that the beneficiated fraction was not suitable for ceramic products where a white colour was necessary.

SAMPLE DESCRIPTION

Approximately 300 kg of material in 10 small (20 L) drums were received in the Non-Metallic Minerals Laboratory in October 1985. A brief examination of a few of the drums showed them to be essentially similar in that the kaolin was a sticky mass associated with coarse silica grains which were up to 10 mm in size. Due to the sticky nature it was difficult to obtain a head sample by conventional sampling; a 10 kg grab sample was carefully prepared from two of the drums.

PROCESSING

HEAD SAMPLE

The head sample was scrubbed in a laboratory 10 kg capacity Wemco scrubber at 85% solids for 30 min to break up the sticky mass and separate the silica grit. After scrubbing, the sample was washed to remove the -44 µm material. The +44 µm fraction was dried and a riffled portion screened. The remaining -44 µm portion was sampled in the wet state. The volume was

measured and a 10 litre sample obtained. This was filtered and allowed to dry slowly at room temperature. The dry weight of -44 μm material in the 10 litre sample was then used to calculate the original weight of -44 μm material in the 10 kg sample.

A 100 g sample was riffled from the dry -44 μm fraction and further sized to 2 μm using a Bahco laboratory air classifier. Each classifier spacer fraction and screen (+44 μm) fraction was chemically analysed. Results are presented in Table 1. A tabulation of cumulative weight percent finer for the Bahco fractions, which comprise the -44 μm product, is presented in Table 2.

CRUSHING

The contents of each drum were passed through a laboratory jaw crusher set at 6 mm, to reduce the kaolin and silica to a size manageable for laboratory processing. Two drums of wet fine kaolin were blended with the crushed product. A 50 kg sample was then carefully prepared by riffling using 12 mm spaced riffle slots.

SCRUBBING AND WASHING

The 50 kg sample was further divided into 10 kg batches and each batch scrubbed in a laboratory Wemco scrubber at 80% solids for 1 hour. Following scrubbing, the scrubbed products were combined and washed to remove the silica grit. This stage was accomplished by two stage screening. The wet slurry was passed through a 210 μm sieve to remove the coarse silica and again through a 44 μm sieve to separate the finer -210 +44 μm silica. After settling of the -44 μm wet slurry the clear water was decanted to reduce the volume of the slurry to a manageable size. The estimated weight of the -44 μm product was 27 kg.

FLOTATION

Although screening at 210 μm and 44 μm removes the bulk of the silica, a portion still remains in the -44 μm product. Kaolin can be separated from fine silica by cationic flotation in an acid environment[2]. Flotation of kaolin from quartz was conducted using ~1.5 kg of flotation feed and employing stage addition of Armac T (tallow amine acetate) collector at pH 2 in the rougher flotation. Stage addition of collector is necessary;

otherwise the fine silica will float with the kaolin. Flotation was also conducted on material deslimed at 2 μm. Desliming was accomplished using a laboratory Mozley hydrocyclone unit. Product balances of the flotation tests are reported in Table 3 and the corresponding reagent concentrations for the flotation tests in Table 4.

MAGNETIC SEPARATION

A 100 g sample of -75 μm material was subjected to high intensity magnetic separation using the Sala HGMS, to remove iron oxides and ilmenite. The results are reported in Table 5.

RESULTS

The chemical analyses of sized fractions in Table 1 indicate that the +44 μm fraction is 85.8% SiO_2 and represents 44.2% weight of the total; the -4 μm fraction as determined by the Bahco laboratory air classifier is 34.0% Al_2O_3 (84.9% kaolin)* and represents 26.3% weight of the total.

The +44 μm fraction could be separated by washing and classification as a fairly clean low grade silica reject product. The 8.7% Al_2O_3 analysis of this fraction is possibly unaltered feldspar which would not break down on scrubbing.

The alumina analyses of the Bahco sized fractions in the -44 μm fraction rise gradually from 12.2% Al_2O_3 for the -44 + 13 μm to 34.1% Al_2O_3 for the -2 μm. In fact, the -4 μm fraction analyses 34.0% Al_2O_3 which could be separated as a high grade kaolin product.

The success of flotation in upgrading the -44 μm product is shown by the results of the product balances in Table 3. Two initial tests, 1 and 2, were conducted on undeslimed feed. In Test 1, insufficient collector in the rougher stage, 412 g/tonne, resulted in a poor rougher recovery of only 45.7%. By increasing the collector concentration to 560 g/tonne the rougher recovery was increased to 71.2% in Test 2. In each test the final

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*It is assumed, based on a previous investigation [1] of the deposit, that the main source of Al_2O_3 is clay and not feldspar. It is noted that the low K_2O analyses could indicate the presence of altered muscovite.

concentrate after two stages of cleaning upgraded to over 30% Al_2O_3 which is equivalent to ~75% kaolin. It was observed in these tests that excessive frothing occurred due to the presence of ultra fine particles; this could have an adverse effect on flotation selectivity. To reduce this effect the -44 µm fraction was deslimed at 2 µm and two further tests conducted on deslimed -44 + 2 µm feed. The result of desliming was to reduce the feed grade from 23.1% Al_2O_3 to 15.8% Al_2O_3.

In Test 3 a rougher collector concentration of 465 g/tonne produced a rougher recovery of 66.3%. When compared to Test 2 the beneficial effect of desliming is seen by the reduction of collector concentration necessary to produce a comparable rougher recovery from 560 to 465 g/tonne. Increased collector addition in the cleaners resulted in both an increase in final recovery to 23.2% and grade to 33.3% Al_2O_3 (83% kaolin). In Test 4, 2.4 kg/tonne of Na_2SiO_3 were added in the rougher float to both aid dispersion and depress silica. The collector concentration was increased to 632 g/tonne which resulted in an increase of rougher recovery to 84.4%. By adding Na_2SiO_3 in the cleaners and further increasing the cleaner collector concentration above the cleaner collector concentration of Test 3, the final recovery was increased to 48.6% for a grade of 32.1% Al_2O_3 (80% kaolin).

CONCLUSIONS

By employing a system of scrubbing, washing, classification and hydrocycloning, a +44 µm silica grit reject product can be separated and a -4 µm, high grade kaolin product, can be recovered.

Flotation can upgrade the intermediate -44 + 4µm fraction to filler grade kaolin but further work would need to be undertaken to improve the recovery. Grades in excess of 80% kaolin would imply filler grade but no brightness measurements have been carried out.

Magnetic separation was only partially successful in reducing iron oxides and ilmenite.

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2. Sutherland, K.L. and Wark, I.W. "Principles of flotation"; Australasian Institute of Mining and Metallurgy; Melbourne, Australia; p. 335; 1955.

Table 1. Chemical analysis of sized fractions from a head sample

Size (μm)	Wt %	Analysis % SiO_2	Al_2O_3	K_2O	Fe_2O_3	TiO_2	Distribution % SiO_2	Al_2O_3	K_2O	Fe_2O_3	TiO_2
+1190	4.9	84.9	8.0	0.47	0.97	0.19	6.1	2.0	1.7	8.3	2.0
-1190+420	6.9	85.1	8.5	0.56	0.55	0.20	8.6	3.0	2.8	6.6	2.9
-420+210	11.1	87.5	8.3	0.56	0.31	0.20	14.2	4.7	4.6	6.0	4.7
-210+105	10.6	86.0	8.5	0.58	0.30	0.22	13.4	4.6	4.5	5.6	4.8
-105 +44	10.9	83.1	9.7	0.67	0.41	0.28	13.3	5.4	5.4	7.8	6.3
-44 +13	2.8	78.3	12.2	0.87	0.50	0.35	3.2	1.8	1.8	1.0	2.1
-13 +10	6.3	74.3	14.5	1.05	0.55	0.40	6.9	4.7	4.9	6.0	5.3
-10 +7	3.4	63.6	21.6	1.55	0.60	0.53	3.2	3.8	3.9	3.6	3.8
-7 +4	16.7	54.2	28.6	2.09	0.66	0.75	13.3	24.4	25.7	19.2	26.5
-4 +2	20.9	47.3	33.5	2.35	0.78	0.76	14.4	35.7	36.1	28.3	33.5
-2	5.7	45.2	34.1	2.05	0.77	0.67	3.4	9.9	8.6	7.6	8.1
TOTAL	100.0	(68.2)	(19.6)	(1.36)	(0.58)	(0.47)	100.0	100.0	100.0	100.0	100.0

Size (μm)	Wt %	Analysis % SiO_2	Al_2O_3	K_2O	Fe_2O_3	TiO_2	Distribution % SiO_2	Al_2O_3	K_2O	Fe_2O_3	TiO_2
+44	44.2	85.8	8.7	0.59	0.45	0.22	55.6	19.7	19.0	34.3	20.7
-44 +4	29.5	63.7	22.9	1.67	0.61	0.60	26.6	34.7	36.3	29.8	37.7
-4	26.3	46.5	34.0	2.31	0.79	0.75	17.8	45.6	44.7	35.9	41.6
TOTAL	100.0	(68.2)	(19.6)	(1.36)	(0.58)	(0.47)	100.0	100.0	100.0	100.0	100.0

Table 2. Cumulative weight % finer for Bahco air classifier products

Size µm	Actual Wt %	Relative Wt %	Cumulative % finer
-44 +13	2.8	5.0	100.0
-13 +10	6.3	11.3	95.0
-10 +7	3.4	6.1	83.7
-7 +4	16.7	29.9	77.6
-4 +2	20.9	37.5	47.7
-2	5.7	10.2	10.2
-44	55.8	100.0	
+44	44.2		
Calculated Head	100.0		

Table 3. Flotation product balances on undeslimed feed material (Tests 1 and 2) and deslimed feed material (Tests 3 and 4)

Test No.	Products	Weight %	Analysis % Al_2O_3	Analysis % Kaolin	Distribution % Kaolin
1	Clean conc. #2	4.3	30.0	74.9	5.6
	Clean tails #2	8.3	25.1	62.7	9.0
	(Clean conc. #1)	12.6	26.8	66.9	14.6
	Clean tails #1	30.7	23.5	58.7	31.1
	(Rougher conc.)	43.3	24.5	61.2	45.7
	Rougher tails	56.7	22.2	55.4	54.3
	Calculated head	100.0	23.2	57.9	100.0
2	Clean conc. #2	9.1	31.6	78.9	12.5
	Clean tails #2	13.0	26.6	66.4	15.0
	(Clean conc. #1)	22.1	28.7	71.6	27.5
	Clean tails #1	43.6	23.2	57.9	43.8
	(Rougher conc.)	65.7	25.0	62.4	71.2
	Rougher tails	34.3	19.4	48.4	28.8
	Calculated head	100.0	23.1	57.7	100.0
3	Clean conc. #2	11.1	33.3	83.2	23.2
	Clean tails #2	8.8	25.6	63.9	14.2
	(Clean conc. #1)	19.9	29.9	74.7	37.4
	Clean tails #1	26.1	17.6	44.0	28.9
	(Rougher conc.)	46.0	22.9	57.2	66.3
	Rougher tails	54.0	9.9	24.8	33.7
	Calculated head	100.0	15.9	39.7	100.0
4	Clean conc. #2	23.4	32.1	80.2	48.6
	Clean tails #2	10.5	18.9	47.2	12.9
	(Clean conc. #1)	33.9	28.0	69.9	61.5
	Clean tails #1	25.3	14.0	35.0	22.9
	(Rougher conc.)	59.2	22.0	54.9	83.4
	Rougher tails	40.8	5.9	14.8	15.6
	Calculated head	100.0	15.5	38.7	100.0

Table 4. Flotation times and reagent concentrations

Flotation Stage	Test 1				Test 2			
	Float Time (min.)	pH	Armac* T	Dowfroth* 250	Float time (min.)	pH	Armac T	Dowfroth 250
Rough. float #1	4	2.0	103	-	3	2.0	112	12
Rough. float #2	4	2.0	103	-	3	2.0	112	-
Rough. float #3	4	2.0	103	-	3	2.0	112	-
Rough. float #4	4	2.0	103	-	3	2.0	112	-
Rough. float #5	-	-	-	-	8	2.0	112	-
Combined rough. float	16	2.0	412	-	20	2.0	560	12
Clean float #1	8	2.2	82	-	10	2.3	-	-
Clean float #2	10	2.5	21	-	10	2.4	-	-

Flotation Stage	Test 3				Test 4				
	Float Time (min.)	pH	Armac T	Dowfroth 250	Float time (min.)	pH	Na_2SiO_3*	Armac T	Dowfroth 250
Rough. float #1	5	2.0	155	9	7	2.0	592	158	-
Rough. float #2	6	2.0	155	-	8	2.0	592	158	9
Rough. float #3	6	2.0	155	-	5	2.0	592	158	-
Rough. float #4	-	-	-	-	4	2.0	592	158	-
Rough. float #5	-	-	-	-	-	-	592	158	-
Combined rough. float	17	2.0	465	9	24	2.0	2368	632	9
Clean float #1	8	2.1	194	-	7	2.0	789	316	-
Clean float #2	6	2.6	116	-	8	2.4	789	158	-

*Reagent concentrations reported as g/t

Table 5. Sala magnetic separation test on -75 µm kaolin

Products	Weight %	Analysis TiO_2	Analysis Fe_2O_3	Distribution TiO_2	Distribution Fe_2O_3
Magnetics	17.7	1.12	0.98	29.3	31.5
Non-magnetics	82.3	0.58	0.46	70.7	68.5
Calculated head	100.0	0.68	0.55	100.0	100.0